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Do Aid and Debt Help the Poor Countries to Catch Up in Technology?

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Do Aid and Debt Help the Poor Countries to Catch Up in Technology?*

Abstract

This paper concentrates on a growth component that the literature on the impacts of foreign aid and debt has often neglected: the focus is on technical efficiency. According to our theory, interactions between the three factors are complicated. System GMM estimations indicate that the joint impact of aid and initial debt on efficiency change is significant and positive. A more robust result is, however, that aid only seems to affect efficiency positively in an environment with good policies. Our results also suggest that an "inefficiency trap" exists so that countries may be stuck in a low-efficiency equilibrium.

JEL Classification: O11, O43, O47

Keywords: aid, debt, technological catch-up, HIPCs.

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1 Introduction

This study is an attempt to contribute to the wide and vibrant discussions on foreign aid effectiveness and the impacts of debt relief. Because these strands of literature have had, and will have implications for practical level decisions on aid allocation and debt relief, it is important to consider the issues from various angles. Here, the focus is on a growth component that has, at least so far, gained less attention: our interest lies in technical efficiency or technological catch-up, and the possible role of aid and debt in improving or retarding growth through this channel. As many arguments for or against aid implicitly refer to the impact of aid on technical efficiency, the aspect is noteworthy. Moreover, aid-growth discussion has, until now, largely neglected to control for external debt, or debt service, even if the literature on debt and growth implies that the level of debt does play a role in economic growth.

We follow Haaparanta and Virta (2007), who calculate scores of technical efficiency for a sample of countries by using data envelopment analysis as in Kumar and Russell (2002). These scores measure the distance of a country to the world technology frontier at a certain time, as illustrated in Figure 1, where point 0 presents the initial input-output combination and point 1 the combination in period 1. The solid line gives the technology frontier at date 0, and the dash line in period 1. In the case depicted in the figure, initial production lies below the output that could have been obtained by using existing technology as efficiently as possible. The distance to the frontier is denoted by the vertical arrow between the observed input-output combination and the frontier, and measures efficiency: the efficiency score equals the ratio of actual output to the potential output at the frontier. The change in output between the two periods can be decomposed into changes in (1) inputs, depicted by the movement along the initial technology frontier, (2) technology, depicted by the shift of the technology frontier, and (3) efficiency, measured by the change in the efficiency score.

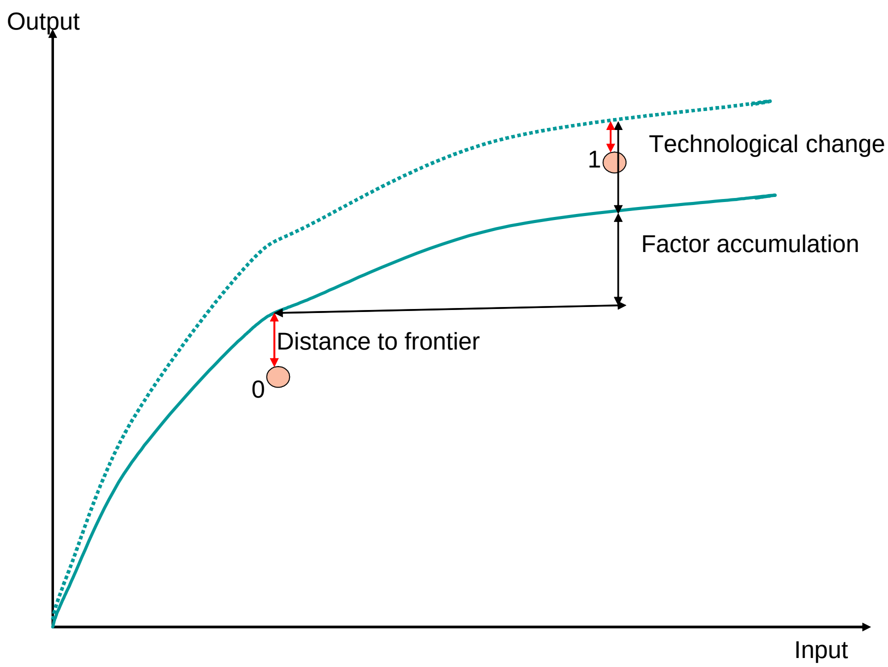

Figure 1. Efficiency scores

Haaparanta and Virta (2007) follow this approach and decompose changes in international labour productivity distribution (distribution of GDP/labour) between 1980 and 2000 into changes in efficiency and technology, as well as physical and human capital accumulation. According to the results, the labour productivity distribution of low-income countries did not change statistically significantly between the two years. The decomposition of the change implies, however, that while capital deculumated between 1980 and 2000, technical efficiency improved. The contrast was especially strong in Highly Indebted Poor Countries (HIPCs), for which Figure 2 gives the decomposition of labour productivity change.

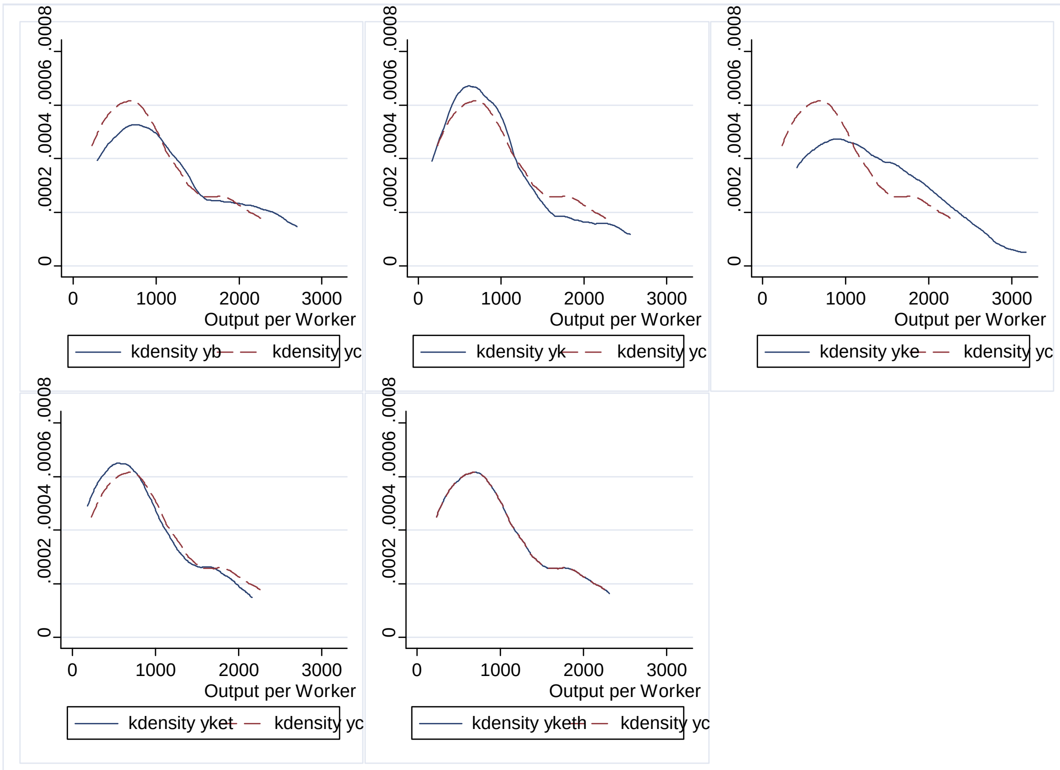

Figure 2. Labour productivity changes in HIPCs between 1980 and 2000

The first diagram of Figure 2 shows the kernel estimates of the labour productivity distributions in 1980 and in 2000 (the latter is depicted by the dash line). Also, b = 1980 and c = 2000. The second diagram depicts labour productivity distribution in 2000 together with the 1980 distribution augmented by physical capital accumulation. The third diagram adds the impact of efficiency change, and the fourth technological change. Finally, the last diagram shows the combined impact of all the underlying changes, including human capital accumulation. As expected, the distributions match in the last diagram.

To summarise the implications of Figure 2, the aggregate changes in labour productivity distribution between 1980 and 2000 were minor in HIPCs. Actually, statistical tests in Haaparanta and Virta (2007) confirm that the distribution did not change statistically significantly between the two years. Changes in technical efficiency had, however, a large, positive, and statistically significant impact on the distribution of labour productivity: they reduced the proportion of countries at low productivity levels and increased the proportion of countries at relatively high output per worker levels, moving therefore the distribution to the right. Although HIPCs thus benefited from improved efficiency, technological change and contraction in capital accumulation nullified the consequences of this positive development. The significantly improved efficiency raises the question of the causes behind the improvement, especially whether foreign aid and debt played any roles. Another question of particular interest is whether, as conjectured by Haaparanta and Virta, poor countries tried to use the existing capital stock as efficiently as possible but, due to lack of funds, were unable even to replace the capital that depreciated.

We begin by reviewing the research on aid-growth and debt-growth nexuses. We then proceed to the theoretical literature on the factors that determine technological catch-up, or distance to frontier, and develop two small models to incorporate some aspects not touched elsewhere. Finally, we present empirical evidence on the impacts of aid and debt on efficiency change. Section 5 concludes.

2 Aid, Debt, and Growth in Literature

This section provides a short literature review on the impacts of foreign aid and external debt on growth. Later, focus will shift to an important, but less studied, component of growth, namely technical efficiency of production.

2.1 The Role of Aid: Conflicting and Not That Robust Results

Literature on aid effectiveness has used various methods from detailed case studies to empirical cross-country analyses, producing at the same time conflicting and not that robust results. The literature can be divided into three generations (Hansen and Tarp 2000). The first two of these were interested in the link between aid and savings, and the relationship of aid, investment and growth, respectively. Hansen and Tarp (2000, 2001) argue that the general conclusion from the cross-country regressions of the first two generations is that aid increases investment and, therefore, growth. According to Hansen and Tarp (2000), some of the more pessimistic results of these generations gained disproportionate attention just because they were contrarian.

As Roodman (2004) lists, the current generation of aid studies has introduced several innovations. The availability of data has improved, which is reflected in the number of countries and years included in the studies. Regressors comprise now economic and institutional variables. The methods have also improved: current research applies two-stage least squares and difference or system GMM (Arellano and Bond 1991; Blundell and Bond 1998) to account for the endogeneity of aid and policy. After an influential study of Burnside and Dollar (2000), discussion has in addition focused on the interaction of aid with other factors. Despite the improvements, poor quality of data means that all the results have to be taken with a grain of salt.

The prominent claim of Burnside and Dollar (2000) is that aid has a positive impact on growth in a good policy environment (including fiscal, monetary, and trade policy), but with diminishing returns. Burnside and Dollar two-stage least squares regressions have, however, been criticised on econometric basis (Hansen and Tarp 2001). Moreover, the results do not seem to be robust to the inclusion of other interaction terms or to expanding the data set (Dalgaard and Hansen 2001; Guillamont and Chauvet 2001; Hansen and Tarp 2001; Roodman 2004). Nevertheless, Burnside and Dollar (2004) support their earlier results with a new data set focusing on the 1990s and an overall measure of institutional quality. They also claim that other methods of aid effectiveness research, such as case studies, data on individual projects financed by aid, and opinion polls, support the view that weak policies limit the effectiveness of aid.

Hansen and Tarp (2001) use difference GMM to overcome the endogeneity problems of Burnside and Dollar regressions. They conclude that aid probably increases growth with decreasing returns[1], but that the joint impact of aid and policy is insignificant, thus undermining the results of Burnside and Dollar. After including investment and human capital in growth regression with the result that aid then does not have any effect on growth, Hansen and Tarp deduce also that aid affects GDP growth through investment. Also Collier and Dollar (2004) find that aid increases investment.[2]

Even if the original results of Burnside and Dollar are not robust, various other studies have offered evidence of a nonlinear relationship between aid and growth. Some of these vouch for the importance

[1] Roodman (2004) conducts several robustness tests for aid-growth regressions. His main finding is that a positive but diminishing return to aid is the only even remotely robust relationship in the data. Collier (2006) also finds quite strongly diminishing returns to aid and discusses various reforms to aid policies to overcome the problem.

[2] Aid can affect technological progress as well as the investment rate: aid tends to have a positive impact on the accumulation of technological knowledge, partly so because roughly 50 % of aid can be categorized as technical grants (Islam 2003). It is, therefore, interesting to see whether this is reflected in changes of economic efficiency.

of interaction between aid and policy, while others find that the joint effect of aid with some other variable is more important.

Among the first group, Collier and Dollar (2002) find evidence of a joint impact of aid and policy in a larger data set and with other policy variable than the one originally used by Burnside and Dollar. Collier and Dehn (2001) incorporate export price shocks into Burnside-Dollar regressions to account for the shock proneness of many small developing countries. Unsurprisingly, the results imply that the shocks play a role: negative shocks reduce growth significantly. At the same time, the addition of the shocks seems to affect the robustness of the Burnside and Dollar results positively. Collier and Hoeffler (2002) find, furthermore, that the effectiveness of aid is heightened in a good policy environment after a civil war. In the same spirit, Islam (2003) concludes that aid effectiveness varies between political regimes: aid seems to have little impact on growth in tinpot countries, but its effect on growth is positive and robust in totalitarian countries.[3]

Among the studies not supporting Burnside and Dollar, Dalgaard and Hansen (2001) show in a theoretical model that good policies can actually reduce the effectiveness of aid. According to their empirical estimations, the conclusion of Burnside and Dollar depends heavily on the data set used. Guillamont and Chauvet (2001) find that the joint role played by the empirical factors contributing to the structural economic vulnerability of a country and aid is crucial, while the interaction between aid and policy is insignificant. The results of Dalgaard et al. (2004) imply, instead, that aid only raises GDP growth outside tropics.

All in all, even if a majority of the recent studies finds that aid affects economic growth positively, the evidence is mixed (Easterly et al. 2004; Roodman 2004).[4] The methods and regressors vary between studies, as do also data sources and time periods. Some aspects have, in addition, been largely neglected. An important shortcoming of aid-growth literature is that the potential role of external debt has barely been studied. Similarly, aid-growth studies do not usually touch all the channels through which aid could work, the only exceptions being the studies on the impact of aid through capital accumulation. For example, there are hardly any studies on the impacts of aid on total factor productivity or technical efficiency.

Because a strict focus on aid-growth connection results often in somewhat limited contributions to policy discussion, decomposing growth into its components could be useful. Therefore, we concentrate on the impact of aid on technical efficiency.[5] In theory, aid can reduce efficiency through several channels, many of which are related to moral hazard. First, aid can be inefficient because, with aid coming, the recipients may not be motivated to initiate beneficial economic and structural reforms. This effect is magnified by two-sided aid dependency: because recipient countries are poor and aid is often a significant proportion of their income, donors know that aid cannot be stopped rapidly. This gives the poor countries some power in aid negotiations and strengthens their incentives not to use the resources as efficiently as possible.

Another side of aid dependency is the dependency of many donor country organizations on aid. Because their existence is based on being a part of the chain of delivering aid, they may be more concerned on distributing the aid promptly and satisfying all the requirements of formal accounting than the quality of aid. For example EU aid has been criticised of this (Martens et al. 2002). Reinikka and Svensson (2005) have shown that the channel through which the aid is distributed matters.

Also other sources of aid inefficiency can be found in donor behaviour. A practice still continuing is tying aid to purchases from donor country firms, which prevents the most efficient use of the funds. Similarly, aid given to donor country NGOs is tied aid. Furthermore, project aid is associated with inefficiency, as it wastes local resources (for example government officials' work), which would be needed somewhere else.

However, there are also channels through which aid can improve technical efficiency. For example, with the help of increased aid, countries can afford to buy latest technology. Thus, the relationship between aid and efficiency is ambiguous, a priori.

[3] Tinpot is a weak form of dictatorship in which the dictator aims at maximizing personal consumption and avoids unnecessary consumption in repression or generating loyalty.

[4] One plausible explanation for this is that even if aid does affect growth positively, the traditional focus on the effect of aid over a short period has lead to misleading results (Clemens et al. 2004).

[5] Kök and Deliktaş (2004) and Hermes et al. (2006) choose the same approach.

2.2 What about Debt?

Also the relationship between external debt and growth has been an important topic in empirical research over the past few years. Given the importance of debt problems in many developing countries and the attempts made to alleviate the problem, this is natural. Empirical analysis can give an idea of how important debt relief is. At the same time, the search for determinants of growth has been very intensive, allowing one to see debt in the broader context of development. Finally, there are some theories of external debt and growth on which empirics can be based.

Theory supports a non-linear relationship between a country's growth rate and its level of external debt relative to GDP. At low levels of debt, external borrowing boosts investment both in human and physical capital, therefore increasing growth. If the debt burden is very heavy, other effects may, however, become stronger. The idea behind the literature on debt overhang is that at high levels of debt, a large share of returns to investment may go to servicing the debt. If the debt is held by the government, this leads to higher taxes. Expectations of higher and more distortionary taxes discourage investment, which then slows down capital accumulation. Analogously, it can be argued that with a severe debt burden, government efforts to enhance overall policy environment benefit mostly creditors. This can affect growth through factor accumulation and total factor productivity.

As to empirical results, the concern about poor-quality data should not be forgotten. Chowdhury (2004) argues, nevertheless, that there is a strong causal link from external debt to growth irrespective of the definition of debt. In addition, there is some evidence of a non-linear relationship between external indebtedness and growth, which supports the debt overhang hypothesis (Clements et al. 2003; Pattillo et al. 2004; Cordella et al. 2005), even though also conflicting views have been presented (Presbitero 2005). At the same time, there seem to be differences between Highly Indebted Poor Countries (HIPCs) and other developing countries: Cordella et al. (2005) and Hepp (2005) find that the level of debt does not seem to affect growth in HIPCs. The most likely explanation is that donors have increased aid to these countries, which has then reduced the impact of the level of debt on growth (Cordella et al. 2005). Thus, it is important to control for aid in the analysis.

There is also evidence of a non-linear relationship between debt and some growth components, total factor productivity growth in particular, even if the literature on the determinants of TFP growth is scarce (Bosworth and Collins 2003; Pattillo et al. 2004). Pattillo et al. (2004) find that TFP growth is negatively affected by lagged income per capita (indicating convergence), positively by human capital and investment, as well as by budget balance and openness, and non-linearly by debt/income ratio. Of these, only lagged income and budget balance are significant in all regressions with different estimation methods.

Interestingly, some debt-growth studies have accounted for foreign aid. In Cordella et al. (2005), aid is included only in a linear form and does not have a statistically significant impact on growth. The same holds for aid interacted with a HIPC-dummy. Hepp (2005) uses both aid and aid^2, and $aid * policy$ and $(aid * policy)^2$, but does not, in general, find them to be statistically significant, except for $aid * policy$ terms for HIPCs. In his estimations, various measures of debt enter only linearly. Presbitero (2005) includes aid and debt and debt service in estimations of an investment equation and finds them statistically significant in many estimations. Also the research of Cohen (1993), Serven and Solimano (1993), and Warner (1992) implies that debt has an impact on investment. Hansen (2004) shows that aid and debt work through their impact on both investment and growth.

We continue this line of work by studying the impact of debt and aid on technical efficiency. Indeed, if aid and debt have affect investment as well as an independent effect on growth (controlling for investment like in Hansen 2004), it is necessary to understand how the growth effect arises. The question is then whether debt and aid have an impact on how a country utilises technological opportunities. This ties our study to the recent discussions on the distance to world technological frontier and its impacts on growth.

3 Aid, Debt, and Efficiency in Theory

Early work on technical efficiency and catch-up was done by Nelson and Phelps (1966). The models presented here are tailored to capture the role of aid and debt in a financially constrained economy and with political considerations.

3.1 Financing Constraints in a Two-Period Model

The basic case with a two-period economy with a benevolent policymaker maximizing the welfare of citizens shows how problems of efficiency may arise even with well-behaved policymakers in the presence of financial constraints.

The utility function of a representative agent is

$$U = u(c_0) - d(e) + \beta u(c_1) \tag{1}$$

and the budget constraints the agent faces are

$$c_0 + I = y_0 + \Delta B - (1 + r_0) B_0 \tag{2}$$

and

$$c_1 = F(K_0, I, e) - (1 + r_1) B_1, \tag{3}$$

where $u() =$ the flow of utility, $\beta =$ time preference, $c_i =$ consumption in period i, $e =$ effort needed to improve the efficiency at which current technology is used, $d() =$ cost of effort in terms of welfare, $I =$ investment, $y_0 =$ initial income, $B_0 =$ initial stock of debt, $\Delta B =$ flow of new funds in period 0 (aid, debt forgiveness, new loans), $r_i =$ rate of interest on loans in period i, $B_1 =$ external debt in period 1[6], and $F(K_0, I, e) =$ gross production in period 1, with $K_0 =$ capital stock at the beginning of period 0. The level of external debt and flow of new funds are determined by foreign financiers and donors and are exogenous to the economy. The economy is thus constrained in its external finance.

Efficiency is modelled as the level of effort put into improving productivity. The cost of effort is incurred today (period 0), but the fruits are picked tomorrow (period 1). The idea behind this formulation is that improving efficiency may require more local effort (for example in reorganizing production and training workers, or costly policy reforms) than just buying new capital goods. The formulation is also consistent with the view that effort is put into reducing the gap to best available techniques. A consequence of the modelling is that the only possible means for the policymakers to engage in intertemporal trade is through the choice of the level of effort.

With these preliminaries, the utility function can be rewritten as

$$U = u\left[y_0 + \Delta B - (1 + r_0) B_0 - I\right] - d(e) + \beta u\left[F(K_0, I, e) - (1 + r_1) B_1\right], \tag{4}$$

which is to be maximised with respect to current investment and effort to improve efficiency.

With the usual assumptions of concave utility functions, convex cost of effort and positive but declining marginal products of investment and effort in period 1 production, it is easy to show that the qualitative properties of the model depend on the sign of the cross derivative of the intertemporal utility function

$$\text{sgn} U_{Ie} = \text{sgn}\left[u"(c_1) F_I F_e + u'(c_1) F_{Ie}\right]. \tag{5}$$

When the sign is positive, investments in e and in I are complements: the higher the initial debt, the lower will both e and I be. An increase in current flow of funds to the economy increases then both efficiency and investment. In contrast, the prospect of future debt forgiveness, $d(1 + r_1) B_1 < 0$, reduces both e and I.

If, on the other hand, $U_{Ie} < 0$, e and I are substitutes. In particular, a higher level of external debt implies higher effort and lower investment. Expected future forgiveness leads to a reduction in effort but increases investment. The impact of debt on growth is ambiguous. This could be called the "Cuba phenomenon": in Cuba US cars from 1950s are still being used, most likely very efficiently compared to their use anywhere else in the world.

[6] Note that B_1 is taken to include also the potential future (period 1) debt forgiveness. Hence, it does not have to equal the debt left from period 0.

The sign of the cross derivative depends on the form of the production function and the level of debt. If the period 1 production function is $F(eK_0 + I)$, the cross derivative is negative. But even if effort and investment are complements in production, they can be substitutes in utility. To show this, assume that the period 1 production function is $A(e)F(K,I)$. Then

$$\text{sgn}U_{Ie} = \text{sgn}A'u'F_I\left[\frac{u"(c_1)\left[c_1 + (1+r_1)B_1\right]}{u'(c_1)} + 1\right] \tag{6}$$

and the sign is determined by the degree of risk aversion and the expected size of the debt. Thus, connection between debt and growth may differ in countries with different debt burdens, which should be controlled for in empirical estimations. The important insight is that a heavy debt burden may reduce aid effectiveness: at high debt levels, increased aid boosts capital accumulation but restrains the effort to utilise the inputs efficiently. At low levels of debt, the connection is one of complementarity: increased aid goes both to investment and efficiency improvement. From the point of view of this model, estimating the change in efficiency requires controlling for the initial debt and the net inflows of new resources, in addition to initial capital stock(s) and/or initial income. That is what is done in the empirical part in Section 4.

Another theory of technological efficiency and financing constraints is developed by Acemoglu et al. (2006). In their model, entrepreneurs, who are the people adopting more efficient existing technologies or innovating new technologies, lack funds and need to borrow from financiers. With imperfect information, there is an agency problem, which is the worse the longer the distance to the technological frontier is. Thus, the model suggests that initial conditions (the prevailing distance to the frontier in particular) have a strong effect on how fast the economy can approach the frontier. While the model is not directly geared to the problem studied here, we account for the potential impact of the existing technology gap. Acemoglu et al. argue also that openness can affect the speed at which the technology gap is closed. We take this into account.

3.2 Aid, Debt, and Politics

A major part of the debate on the impacts of aid and debt concerns the relationship between aid, debt and domestic policies. The next model incorporates some of the potential channels between these variables.

3.2.1 The Framework

There are three types of agents. The first type is the ruler, who makes the decisions as long as she is in power. She can voluntarily yield up her power to citizens, who are the second type of agent. In this case, the economy switches to democracy. The third type of agent is the external financier/donor. All the agents are infinitely lived, and time is divided into discrete periods. The actions within each period are as follows: first, if the ruler is still in power at the beginning of period, she decides whether to give power to the citizens or not. After that the ruler, assuming she remains in power, decides how to tax the citizens and, simultaneously, citizens decide how to produce. As in Acemoglu (2003)[7], citizens have two alternatives: they can produce either in formal or informal economy. In the former, income is fully taxable, while in informal economy it is not. This is where technical efficiency enters the picture: production technology is less efficient in the informal sector than in formal economy. Thus the choice of production method is the link between policies, institutions, and productive efficiency. The third type of actor, the external financier sets debt repayment schedule and gives aid. The per period debt repayment is $G^i(j)$, $i = dic$, dem, where dic = dictatorship (if the ruler is still in the power at the end of the period) and dem = if the political system is democracy. The donors can tie debt payments/forgiveness and aid on policies and the state of the economy indexed by j, which is a way to incorporate odious debt, the share of which is estimated to be between 30 and 60 per cent of the total developing country debt (Birdsall et al. 2002). It is assumed, for simplicity, that the donor

[7] Our set-up is inspired by Acemoglu (2003) in many respects. There are two main differences to Acemoglu's work. First, we assume that the ruler and the citizens act simultaneously in the second stage and we include the external actor. Second, we assume that there are tax collection costs.

is passive in the sense that the debt repayment schedule is fixed, and that the donor does not make any strategic decisions.

The crucial decision of the citizens is where to produce. Consider first an economy without debt and aid. The intertemporal welfare of a citizen in period t is

$$u_t = \sum_{\tau=0}^{\infty} \beta^{\tau-t} \left[c_{t+\tau} - (1-\alpha)\, e_{t+\tau}\right], \tag{7}$$

where $c_{t+\tau}$ = consumption and $e_{t+\tau}$ = effort by the citizen in period $t+\tau$. There is a continuum $[0,1]$ of citizens (the citizen index has been dropped). If the citizen chooses to work in the formal sector, her output is

$$y_{t+\tau} = \left(e_{t+\tau}\right)^{1-\alpha}, 0 < \alpha < 1 \tag{8}$$

and her total income, gross of taxes and potential debt repayments, is

$$I^f = y_{t+\tau} + R \tag{9}$$

where R = citizen's income from a natural resource. If she chooses to work in the informal sector, her output is

$$x_{t+\tau} = b^{\alpha}\left(e_{t+\tau}\right)^{1-\alpha}, 0 < b < 1 \tag{10}$$

and total income

$$I^{in} = x_{t+\tau} + R \tag{11}$$

where b is a measure of productive inefficiency in the informal sector. The larger the proportion of citizens working in the formal sector, the more efficient the economy is. All taxes to be imposed are lump sum. Under these assumptions, the optimal effort in the formal sector is $e^f_{t+\tau} = 1$ = output in the formal sector, while the optimal effort in the informal sector is $e^{in}_{t+\tau} = b$ = output in the informal sector.

The utility function of the ruler is

$$u^{dic}_t = \sum_{\tau=0}^{\infty} \beta^{\tau-t} c^{dic}_{t+\tau}. \tag{12}$$

If the ruler yields up her power, her consumption and utility equal 0. If she is in power, she can only finance her consumption through taxes. She can always tax the income from the natural resource, but otherwise she can tax citizens' income only when they produce in formal economy.

Consider first the game between the ruler and the citizens in the absence of debt and aid. We focus on the Markov-perfect equilibria. The only pay-off relevant state variable is the political system. When the end-of-period political system is democracy, the citizen's welfare is

$$u_t\,(dem) = \frac{R+\alpha}{1-\beta}, \tag{13}$$

because the citizens do not have motives to tax themselves in this set up. The (ex-)ruler's welfare is

$$u^{dic}_t\,(dem) = 0. \tag{14}$$

If, in contrast, the economy is still a dictatorship at the end of the period, the dictator faces tax collection costs which are increasing in the ratio of taxes relative to the tax base.[8] For simplicity, the

[8] For example Aizenman (2003) argues that tax collection costs are empirically significant. One way to rationalize the assumption made here is that tax administration has to "catch" the taxpayers who are scattered in the economy and who can change the location of their activities. The larger taxes are relative to the tax base, the larger tax administration is needed to collect the taxes.

costs are linear in the ratio: $C = f(taxes/tax\ base)$, $1 > f > 0$. We assume, again for simplicity, that the ruler sets either high taxes, $T = 1 + R$, or low taxes, $T = R$. Simultaneously, citizens choose whether to work in the formal or informal sector. Bearing in mind that even if the ruler sets high taxes, but the citizen works in the informal sector, the ruler can only collect the revenue from the natural resource, the payoffs are:

$$\begin{array}{cc|cc} & & \multicolumn{2}{c}{\text{Citizen}} \\ & & \text{Formal} & \text{Informal} \\ \text{Ruler} & \text{High} & 1+R-f,\ \alpha-1 & R-f\left(\frac{1+R}{R}\right),\ \alpha b \\ & \text{Low} & R-f\left(\frac{R}{1+R}\right),\ \alpha & R-f,\ \alpha b \end{array} \tag{15}$$

First, there is not any pure strategy equilibrium, but a mixed strategy equilibrium exists. Thus, let $p =$ probability that citizens choose to work in the formal sector and $q =$ the probability that the ruler sets high taxes. The ruler must be indifferent between the two tax rates:

$$\begin{aligned} & p\,(1+R-f) + (1-p)\left[R - f\left(\frac{1+R}{R}\right)\right] \\ &= p\left[R - f\left(\frac{R}{1+R}\right)\right] + (1-p)\,(R-f) \end{aligned} \tag{16}$$

giving the equilibrium citizens' strategy as

$$p = \frac{\frac{f}{R}}{1 + \frac{f}{R(1+R)}} = \frac{f\,(1+R)}{R\,(1+R)+f}. \tag{17}$$

Interestingly, the probability of citizen's working in the formal sector goes to zero, as the resource rent goes to infinity: there is a resource curse. Similarly, in equilibrium the citizen is indifferent between working in the formal or informal sector only if

$$q(\alpha - 1) + (1-q)\,\alpha = q\alpha b + (1-q)\alpha b \tag{18}$$

giving the equilibrium probability of the high tax rate as

$$q = \alpha\,(1-b)\,. \tag{19}$$

With these probabilities, the expected ruler income is strictly positive. Hence, the ruler chooses to stay in power.

3.2.2 The Consequences of Debt Relief

Including debt in the model makes the situation more complicated. When the economy is a democracy, debt repayments fall on the citizens and their welfare is, assuming that they produce in the formal sector,

$$u_t\,(dem) = \frac{R + \alpha - G^{dem}\,(rich)}{1-\beta} \tag{20}$$

while the ruler's utility equals zero. Here $G^{dem}\,(rich) =$ debt repayments, when all citizens produce in the formal sector. If the citizens work in the informal sector, only resource income can be used for debt repayment. If all the citizens work in informal economy, an expression analogous to (20) holds for welfare. In this set-up, a citizen chooses to work in the formal sector only if $R + \alpha - G^{dem}\,(rich) \geq \alpha b + R - G^{dem}\,(poor)$. This implies that debt relief focusing on poor countries may be a hindrance to economic growth: if $R - G^{dem}\,(poor) > 0$, formal sector production is profitable only if also $R - G^{dem}\,(rich)$ is large enough, that is debt relief is provided also when income level is higher. Another means of achieving the same goal is to increase aid to countries that show growth in per capita income. Thus, debt relief may have adverse incentive effects, unless it is planned to encourage growth. Also debt overhang problem is possible. If the debt burden in the dictatorship is large, $1 + R > G^{dic}\,() > R$

and no debt relief is provided when the country switches to democracy, formal sector production is chosen only if $\alpha b < \alpha + R - G^{dic}()$. Thus, odious debt, debt given to dictators may prevent economic development without debt relief.

In dictatorship, the same game is played between the ruler and the citizens, but the debt repayments fall on the ruler. The equilibrium probability[9] of the citizens choosing to work in the formal sector is now

$$p = \frac{\frac{f}{R} + G^{dic}(HT, poor) - G^{dic}(LT, poor)}{1 + \frac{f}{R(1+R)} + G^{dic}(HT, poor) - G^{dic}(LT, poor) - [G^{dic}(HT, rich) - G^{dic}(LT, rich)]}, \tag{21}$$

where HT refers to the case where the dictator sets high taxes, and LT to the case with low taxes. Comparing (17) and (21) shows that debt relief conditioned on government policies can be used to enlarge formal economy, while the equilibrium probabilities of choosing high or low taxes remain unchanged. In particular, debt relief provided when the dictator chooses good, low-tax, policy increases the size of the formal sector, improving therefore economic efficiency. After all, such debt relief implies a reduction in both $G^{dic}(LT, poor)$ and $G^{dic}(LT, rich)$. The same can be achieved through aid: aid conditioned on good policies enlarges the formal sector.

Consider next the case with $1 + R > G^{dic}() > R$. Then, if the citizens choose to work in the informal sector or low taxes are chosen, the ruler cannot meet the scheduled repayments and can only pay R. The equilibrium probability of citizens choosing the formal sector production becomes

$$p = \frac{\frac{f}{R}}{1 + \frac{f}{R(1+R)} - [G^{dic}(HT, rich) - R]}. \tag{22}$$

In this special case, higher debt burden improves economic efficiency. At the same time, resource curse becomes more serious. This is in contrast with the mild debt burden case (equation (21)), where increased debt burden could improve or reduce efficiency. Finally, with severe enough debt burden the dictator can never achieve high enough income to get higher utility by staying in power than by giving power to the citizens: debt burden can initiate political change. This political change will improve efficiency, if accompanied with debt relief.

To recapitulate the main results thus far: debt can interact interestingly with the political regime and affect productive efficiency through this channel. With a moderate debt burden, increases in debt may reduce productive efficiency under autocratic regime. The reverse happens when the debt burden is severe. Debt burden can also lead to a political change and birth of democracy if the donors behave properly. In democracy, debt burden can lead to productive inefficiency if it is severe enough. Thus, debt relief when a country becomes democratic can be a reasonable policy.

3.2.3 The Role of Aid

Let us now finally add aid to the model. Because aid directed to the dictator has similar effects with debt relief, such aid (or fungible aid given to the citizens) conditioned on good policy improves efficiency. Thus, consider non-fungible aid given to the citizens. Obviously, it does not affect the choice of the sector of production. Instead, it has an impact on the choice of tax policy, and the equilibrium probability of high taxes becomes

$$q = \frac{\alpha(1-b) + A^{dic}(LT, rich) - A^{dic}(LT, poor)}{1 + A^{dic}(HT, poor) + A^{dic}(LT, rich) - [A^{dic}(LT, poor) + A^{dic}(HT, rich)]}, \tag{23}$$

where A() denotes aid given to the private sector. (23) shows that the more selective aid is in the sense of being conditioned on private sector poverty, that is the larger $A(LT, poor)$ and $A(HT, poor)$ are, the smaller is the probability that policies are unfavourable. Thus, aid given to the dictator and conditioned on good policies and aid given to the private sector and conditioned on poverty can

[9] We assume here and in the following subsection that debt and aid do not change the nature of the equilibrium and do not produce additional equilibria. This is done to highlight that, even with this simplification, the implications of debt and aid on efficiency depend on details.

mutually reinforce each other. Increased aid can then either reduce or improve productive efficiency and improve or worsen policies, when the political system is autocracy.

The same holds for democracy, but with an interesting twist. In democracy, if $G^{dem} < R$, citizens choose to produce in the formal sector only if

$$R + \alpha - G^{dem} + A^{dem}(rich) \geq R + \alpha b - G^{dem} + A^{dem}(poor) \tag{24}$$
$$\Leftrightarrow$$
$$\alpha(1-b) \geq A^{dem}(poor) - A^{dem}(rich).$$

Thus, aid too much conditioned on poverty may reduce efficiency: (24) would not hold. Unconditional aid with debt relief (if needed) is consistent with efficiency.

Altogether, the theory implies that interactions between aid, debt, institutions, and donor behaviour affect productive efficiency. The interactions are not straightforward, however. Policies that improve efficiency when the economy is autocratically led may have a negative impact in democracy. Autocracy includes in the present setting a very corrupted democratic regime where a large part of the income is absorbed by a small class of policymakers and bureaucrats. The overall conclusion is then that one should control for aid, debt, and policy with multiplicative terms in the empirical part..

An additional implication of the model is that both with and without aid and debt, the economy can be caught in an "inefficiency trap". First, a dictatorship will not become a democracy without aid and debt. Because efficiency would be higher in democracy without informal economy, this will result in inefficiency. Second, debt and aid can reduce efficiency even in a democracy. The model of Acemoglu et al. (2006) is also consistent with the existence of an inefficiency trap. By controlling for aid, debt, and institutional quality in empirical estimations, we can control for the variable creating the trap, but only partially.

4 Empirical Analysis

Our analysis differs from the earlier literature by concentrating on the impact debt and aid have on technical efficiency: we study whether debt and aid contribute to aggregate economic efficiency by improving poor countries' use of available technologies. To do that, we need a measure of efficiency. One possible approach is that followed by Acemoglu et al. (2006), who measure the distance to frontier by international differences to US labour productivity, so that US economy alone determines the world technology frontier. Instead of making that assumption, we use data envelopment analysis (DEA) as explained in introduction, and let the group of efficient countries jointly determine the efficient frontier. The scores given to individual countries measure the distance of a country from the world production frontier. Kök and Deliktaş (2004) use the same approach, but concentrate on transition economies instead of a wider set of developing economies. Their results, based on regressing the average efficiency change on initial efficiency, aid, foreign direct investment and an index of democratization, indicate that aid had a positive impact on the average efficiency change in transition economies during 1991-2002. However, Kök and Deliktaş do not account for the endogeneity of aid.

Another option closely associated with DEA would have been to use stochastic frontier analysis. Hermes et al. (2006) use this method to explain the impact of aid on technical efficiency. They have data on 38 developing countries, while we rely on a slightly larger data set. Moreover, our set of controls is more extensive.

4.1 Data

Our dependent variable is the change in (log) efficiency. Haaparanta and Virta (2007) calculate DEA efficiency scores for 83 countries, of which 25 belong to the group of high-income countries, with 5-year intervals between years 1980 and 2000. The use of the original efficiency scores would, therefore, leave us with only four 5-year periods with further reductions in periods when the aim is at explaining change, and when regressors are meant to include the lagged dependent variable. To overcome this problem, we expand the original data set of Haaparanta and Virta to cover years 1978-2001, and concentrate on 4-year periods (1978-1981, 1982-1985, 1986-1989, 1990-1993, 1994-1997, 1998-2001) instead of 5-year periods. We also calculate the efficiency scores for 2002 to be able to explain the change in efficiency between years 1998 and 2002.

As to the other variables used in the regressions, initial GDP per capita, population growth, schooling measured by the mean years of secondary schooling among those over 25, budget surplus, updated Sachs-Warner indicator of openness, both of the two aid measures, as well as the index of institutional quality originate from a data set collected by Roodman (2004). The data set comprises many of the variables that have traditionally been used to analyse the role played by aid and utilises various sources. We add variables necessary for our purposes, the most important addition being the level of debt. To measure debt, initial external debt per GDP and total debt service per exports from WDI Online database (World Bank 2006) are used as well as the net present value of debt from Dikhanov (2007). Other variables from the World Bank include gross fixed capital formation per GDP, foreign direct investment per GDP, and growth rate of net barter terms of trade (which is also based on authors' calculations). Data on Frankel and Rose trade instrument originates from Andrew Rose's home page (see also Frankel and Rose 2002). More detailed variable descriptions and data sources (Table A.1) as well as descriptive statistics (Table A.2) are presented in Appendix A.1.

As is commonly done in cross-country growth studies, annual observations are transformed into period averages of flows and initial observations of stocks. The resulting data set is an unbalanced panel covering efficiency changes from 1978-1982 to 1998-2002. Appendix A.2 lists the countries included in the analysis.

4.2 Methodological Issues

There are at least two methodological issues that need special attention. First, it is not straightforward to use efficiency scores calculated by data envelopment analysis as a left hand side variable (Simar and Wilson 2000, 2006). There are several potential problems here. The first one is that efficiency scores lie between zero and one. Since we focus on the change in efficiency scores (change in logs, more specifically), we avoid that problem here. The other problem, identified by Simar and Wilson, is that efficiency estimates calculated by DEA are serially correlated. Thus, if one tries to explain the efficiency levels, standard statistical inference is not valid. We hope to mitigate the problem by focusing on the change in efficiency estimates. Also, we do not use the whole sample of countries for which the efficiency scores are calculated, but a subsample consisting of those developing countries that have received foreign aid. As the residuals of our regressions discussed below are not autocorrelated within a period[10], our approach seems to work. Finally, possible endogeneity of the regressors needs to be taken into account. This necessitates a careful choice of the estimation method.

As is well known (Caselli et al. 1996), growth equations tend to be characterised by dynamics and endogenous regressors. Hansen and Tarp (2001) find that also most of the explanatory variables recently used in the literature on the effects of aid on growth are endogenous. They suspect, particularly, that aid is not exogenous with respect to growth and question whether it is even predetermined in a typical cross-country regression with variables averaged over four or five years. As GDP figures have been used to compile the efficiency scores, it is more than likely that the same applies to the equations estimated here. This implies that neither generalised least squares nor fixed effect estimator will produce consistent estimates (Bond 2002).

One solution to the problem is to use the dynamic panel general method of moments (GMM) estimator by Arellano and Bond (1991), also called difference GMM. As discussed in more detail below, it is an instrumental variables estimator that uses suitable lags of the predetermined and endogenous variables as instruments for those predetermined and endogenous variables in first differences. Using the estimator requires that the error terms are not serially correlated. Another option is Blundell and Bond system GMM estimator (Blundell and Bond 1998). System GMM estimator adds the original equations in levels to the system of first-differenced equations. The validity of the additional instruments hinges on the assumption that changes in the instrumenting variables are uncorrelated with the fixed effects. Difference-in-Sargan test can be used to test the validity of a subset of instruments (see for example Roodman 2006). Difference and system GMM estimators are discussed in the connection

[10] Test results are available upon request.

of debt and growth by Presbitero (2005), Cordella et al. (2005), and Pattillo et al. (2004), and in the context of aid and growth by Dalgaard et al. (2004) among others.

4.3 Results from Difference and System GMM Estimations

We base our estimations on Pattillo et al. (2004) and add regressors that should not be neglected according to our theory. As discussed above, Pattillo et al. find that TFP growth is negatively affected by lagged income per capita, while it seems to be positively affected by human capital and investment, as well as by budget balance and openness. The role played by debt/income ratio seems to be non-linear. Only lagged income and budget balance are significant in all regressions. Pattillo et al. control for the level of debt, but do not take aid into account. This is where we depart from their approach: we try to account for the impacts of aid as well as debt and try also to examine the role of possible non-linearities.

The equation to be estimated is

$$\begin{aligned} \triangle e_{it} &= \alpha + \beta e_{i,t-1} + \sum_{j=1}^{k} \gamma_j x_{jit} + \eta_i + \varepsilon_{it} \text{ with} \\ \mathrm{E}\left[\eta_i\right] &= \mathrm{E}\left[\varepsilon_{it}\right] = \mathrm{E}\left[\eta_i \varepsilon_{it}\right] = 0 \end{aligned} \tag{25}$$

where e_{it} is the logarithm of the DEA efficiency score of country i at time t, x_{jit} is the set of control variables, including aid and debt, and η_i is an unobserved country-specific time-invariant effect, and ε_{it} is a disturbance term. Differencing removes the country-specific effects and leads to

$$\triangle e_{it} - \triangle e_{i,t-1} = \beta\left(e_{i,t-1} - e_{i,t-2}\right) + \sum_{j=1}^{k} \gamma_j \left(x_{jit} - x_{ji,t-1}\right) + \varepsilon_{it} - \varepsilon_{i,t-1}. \tag{26}$$

Although predetermined variables become endogenous in first differences, deeper lags are potential instruments. Difference GMM uses this attribute and instruments the predetermined and endogenous variables[11] in first differences with suitable lags of their levels. Therefore, x_{jit} is a vector of current and lagged values of explanatory variables. The result is a system of equations with one equation for each time period. However, if e is near random walk, $e_{i,t-1}$ is a poor instrument for $\triangle e_{it}$ (Blundell and Bond 1998). In such a case, system GMM performs better. As mentioned above, system GMM adds the original equations in levels into the system. The predetermined and endogenous variables in levels are then instrumented with suitable lags of their own first differences. The main assumption is that $\mathrm{E}[\eta_i \triangle \varepsilon_{it}] = 0$, meaning that the country-specific effects should not be correlated with changes in the disturbance term.

Both difference and system GMM estimators have one- and two-step variations. The one-step GMM estimator is only efficient under homoskedasticity and uncorrelated error terms, while the two-step estimator is asymptotically more efficient (Presbitero 2005). The latter exploits the residuals from the one-step estimate and uses a consistent estimate of the weighting matrix (Davidson and McKinnon 2004). However, the two-step estimates of the standard errors tend to be downward biased (Arellano and Bond 1991; Blundell and Bond 1998). This can be compensated for by using a finite-sample correction for the asymptotic variance of the two-step GMM estimator of Windmeijer (2005). This correction is built into the Stata module xtabond2 by Roodman (2005), and is used here in all the two-step regressions. In addition, small sample statistics are reported throughout.

The number of instruments is quadratic in T, which can lead to problems because too many instruments tend to overfit endogenous variables. Therefore, the number of lags of the instrumenting variable is restricted to lags 1 and 2 in the transformed equation and lag 0 in the levels equation for predetermined variables. As to endogenous variables, we follow a standard treatment and use lags 2

[11] As defined in Bond (2002), a variable x_{it} is endogenous, if it is correlated with ε_{it} and earlier shocks, but uncorrelated with $\varepsilon_{i,t+1}$ and subsequent shocks. It is predetermined if it is uncorrelated with ε_{it} but correlated with $\varepsilon_{i,t-1}$ and earlier shocks. If x_{it} is exogenous, it is uncorrelated with all past, present and future realizations of ε_{is}.

and 3 in the transformed equation and lag 1 in the levels equation. Moreover, the set of instruments is collapsed in a manner described in Roodman (2006).

Table 1 presents the regressions most closely based on Pattillo et al. (2004). Uneven columns use difference GMM, while even columns use system GMM. Constant is only included in the latter, because it is automatically dropped from difference GMM estimations. The two-step estimator with the finite-sample correction of Windmeijer is used in all the regressions, while some test statistics are presented at the bottom of the table. The dependent variable is the change in log efficiency. As in all of our specifications, the controls include lagged efficiency change, log initial efficiency and log initial income per capita. Population growth, human capital as measured by mean years of secondary schooling among those over 25, gross capital formation relative to GDP, budget balance, Sachs-Warner measure of openness, terms of trade growth and the level of debt are taken from Pattillo et al. (although data sources vary). To these, we add foreign direct investment relative to GDP and lagged aid, as well as an interaction term of aid and debt.[12] Our primary aid variable is effective development assistance divided by real GDP from Roodman (2004), but we test for the robustness of the results by using the ratio of net overseas development assistance and real GDP also from Roodman. In the spirit of Hansen and Tarp (2001), we lag aid by one period. This policy is also followed when interaction terms of aid and other variables are built. As to debt, we use both the face value of debt stocks and the present value of debt. Period dummies are included to control for time and to make the assumption of no correlation across individuals in the idiosyncratic disturbances more likely to hold (Roodman 2006).

[12] Because of the existing evidence of non-linearities of the impacts of aid and debt, we initially included also aid and debt squared in the regressions with the result that correlation between the squared variables and the variables in levels had a large, and apparently misleading, impact on the results.

Table 1. Difference and system GMM regressions on the impacts of aid and debt on efficiency change

	Regression 1	Regression 2	Regression 3	Regression 4	Regression 5	Regression 6
	difference GMM	system GMM	difference GMM	system GMM	difference GMM	system GMM
Efficiency change (lagged)	0.125	**0.174**	0.07	**0.166**	0.064	**0.156**
	(1.48)	**(1.97)***	(0.63)	**(1.73)***	(0.7)	**(2.10)****
Log initial efficiency	**-0.537**	**-0.261**	**-0.522**	**-0.215**	**-0.5**	**-0.218**
	(4.76)***	**(2.27)****	**(3.91)*****	**(2.44)****	**(2.85)*****	**(2.59)****
Log initial real GDP / capita	**-0.511**	0.037	**-0.553**	0.082	**-0.538**	**0.101**
	(2.90)***	(0.57)	**(3.38)*****	(1.53)	**(2.79)*****	**(2.23)****
Population growth	**0.091**	**0.089**	**0.096**	**0.085**	**0.093**	**0.089**
	(2.85)***	**(2.05)****	**(3.86)*****	**(2.32)****	**(4.37)*****	**(2.04)****
Schooling	0.271	0.036	**0.395**	0.015	**0.369**	0.005
	(1.02)	(0.71)	**(2.18)****	(0.3)	**(1.98)***	(0.14)
Gross fixed capital formation / GDP	-0.015	**-0.013**	**-0.017**	**-0.014**	**-0.018**	**-0.014**
	(1.5)	**(1.98)***	**(2.02)****	**(4.22)*****	**(2.41)***	**(3.84)*****
Foreign direct investment / GDP	0.001	0.009	0.018	0.001	0.02	-0.004
	(0.02)	(0.74)	(0.72)	(0.09)	(0.7)	(0.34)
Growth rate of net barter terms of trade	0.001	0.001	0.001	0.001	0.001	0.001
	(0.66)	(0.57)	(1.07)	(0.83)	(0.93)	(1.1)
Budget surplus	-1.794	-0.234	-1.47	**-1.068**	-1.371	-0.889
	(1.58)	(0.25)	(1.43)	**(1.78)***	(1.58)	(1.25)
Sachs-Warner	0.006	0.029	0.006	-0.02	-0.003	0.01
	(0.11)	(0.57)	(0.07)	(0.41)	(0.04)	(0.21)
Total debt service / exports	-0.001	-0.001	0.001	0	0.001	0
	(0.28)	(0.26)	(0.28)	(0.07)	(0.15)	(0.07)
Aid (lagged)	0.02	-0.016	**0.044**	-0.025	**0.04**	-0.018
	(1.25)	(0.94)	**(1.77)***	(1.34)	**(1.98)***	(1.05)
Aid (lagged) * initial external debt / GDP	0.006	0.005	0.006	**0.006**	0.006	**0.009**
	(0.6)	(1.04)	(0.81)	**(2.27)****	(0.86)	**(2.00)***
Aid (lagged) * policy			-0.003	**0.011**		
			(0.49)	**(2.29)****		
Debt * policy					-0.002	**0.008**
					(0.66)	**(1.95)***
s1982	-0.021	0.051	0.053	-0.014	0.052	-0.001
	(0.17)	(0.69)	(0.38)	(0.24)	(0.44)	(0.02)
s1986	-0.115	-0.088	-0.058	-0.132	-0.058	-0.125
	(1.09)	(1.63)	(0.46)	(3.14)***	(0.51)	(2.81)***
s1990	-0.082	-0.03	-0.048	-0.044	-0.048	-0.046
	(1.24)	(0.92)	(0.74)	(1.59)	(0.72)	(1.73)*
s1994	-0.021	0.01	-0.008	0.013	-0.009	0.006
	(0.63)	(0.49)	(0.23)	(0.76)	(0.28)	(0.37)
Constant		-0.348		-0.597		-0.756
		(0.79)		(1.46)		(2.00)*
t statistics in parentheses (* significant at 10%; ** significant at 5%; *** significant at 1%)						
Observations	162	215	158	210	158	210
Number of groups	47	48	45	48	45	48
Number of instruments	28	41	30	44	30	44
Arellano-Bond test for AR(2) in first differences (P-value)	0.497	0.372	0.212	0.702	0.226	0.813
Hansen test of overidentifying restrictions (P-value)	0.656	0.193	0.733	0.692	0.738	0.582
Difference-in-Sargan test (P-value)						
GMM instruments for levels		0.384		0.884		0.705
Predetermined instruments		0.242		0.715		0.658
Endogenous instruments		0.839		0.820		0.815

Notes: Null hypotheses of the tests are as follows: Arellano-Bond test for autocorrelation: null = no autocorrelation; Hansen test: null = the set of instruments is valid; difference-in-Sargan test: null = the level moment conditions imposed in system GMM are valid.

The first regression in Table 1 implies that log initial efficiency has a negative impact on efficiency change, meaning that the impact of initial DEA score is positive. Opposite result would have been more intuitive given the upper limit of efficiency: countries already efficient or otherwise close to the world technology frontier have little room for improvement. But, as discussed above in the theory section, an "inefficiency trap" can exist. With some countries caught in such a trap, higher initial efficiency could imply higher future efficiency, and low initial efficiency low efficiency also in the future. Our results indicate that improvements in efficiency are relatively larger at low levels of initial efficiency. This is also consistent with the existence of an inefficiency trap: one would expect that once countries get out of the trap, their efficiency initially increases fast.

Of the other significant regressors, population growth seems to have a positive impact on efficiency change. One possible interpretation of this result is that growth in population is a proxy for improved health. Another, complementary interpretation is that the coefficient captures factors such as an end of civil war. Finally, the result may reflect "population pressure": with more mouths to feed one must use existing production facilities more efficiently. As to the variables of interest, neither aid nor debt seems to be significant in determining the efficiency change in any of the difference GMM estimations of columns 1, 3 and 5. Hansen J statistic test for over-identifying restrictions indicates that the set of instruments is valid, and Arellano-Bond test for AR(2) in first differences implies that the error terms in levels are not serially correlated, as required.

Regression 2 presents the results with system GMM.[13] The positive relationships between efficiency change and initial efficiency, and efficiency change and population growth hold even with the additional instruments in levels. The negative impact of investment rate now apparent is not surprising: because DEA scores use physical capital stock as an input, larger stock may result in inefficiency in the use of inputs. Instead, if there is shortage of physical capital, it will probably be used more efficiently (Haaparanta and Virta 2007).

Regressions 3 and 4 incorporate an interaction term of aid and policy[14] because earlier literature, most notably Burnside and Dollar (2000), has implied that policy might play a role. According to system GMM regression 4, the impact of aid is significantly linked to the policies followed by the recipient country. Moreover, aid and debt are jointly significant with a positive impact on efficiency change. For completeness, regressions 5 and 6 incorporate interaction between debt and policy instead of that of aid and policy. The interaction term $aid * debt$ is again significant and positive, as is also the impact of $debt * policy$.

Table 2 presents one-step results for the system GMM regressions of Table 1. The impacts of initial efficiency, population growth and investment are as in Table 1, and the joint impact of aid and initial debt is now significant in all three regressions.

[13] Difference-in-Sargan test results at the bottom of the table imply that system GMM can be used.

[14] Policy is defined as in Burnside and Dollar (2000), that is policy = 6.85 * budget balance - 1.4 * inflation + 2.16 * Sachs-Warner.

Table 2. One-step system GMM regressions on the impacts of aid and debt on efficiency change

	Regression 1 system GMM	Regression 2 system GMM	Regression 3 system GMM
Efficiency change (lagged)	**0.146**	**0.125**	**0.126**
	(2.46)**	**(1.97)***	**(2.02)****
Log initial efficiency	**-0.22**	**-0.168**	**-0.181**
	(3.16)***	**(2.05)****	**(2.64)****
Log initial real GDP / capita	0.013	0.057	**0.074**
	(0.3)	(1.15)	**(1.74)***
Population growth	**0.085**	**0.084**	**0.086**
	(2.28)**	**(2.23)****	**(2.30)****
Schooling	0.049	0.039	0.022
	(1.44)	(1.19)	(0.67)
Gross fixed capital formation / GDP	**-0.011**	**-0.013**	**-0.013**
	(2.49)**	**(2.96)*****	**(3.79)*****
Foreign direct investment / GDP	0.009	-0.001	-0.004
	(0.75)	(0.12)	(0.36)
Growth rate of net barter terms of trade	0.001	0.001	0.001
	(1.08)	(1.06)	(1.23)
Budget surplus	-0.121	-0.581	-0.42
	(0.21)	(1.15)	(0.84)
Sachs-Warner	0.018	-0.042	-0.018
	(0.36)	(1.06)	(0.38)
Total debt service / exports	0	0	0
	(0.11)	(0.16)	(0.12)
Aid (lagged)	-0.014	-0.018	-0.014
	(1.2)	(1.22)	(1.05)
Aid (lagged) * initial external debt / GDP	**0.005**	**0.007**	**0.009**
	(1.72)*	**(3.09)*****	**(2.10)****
Aid (lagged) * policy		0.008	
		(1.17)	
Debt * policy			**0.007**
			(1.93)*
s1982	0.048	-0.007	-0.002
	(0.87)	(0.14)	(0.04)
s1986	-0.104	-0.139	-0.137
	(2.42)**	(3.46)***	(3.19)***
s1990	-0.04	-0.058	-0.058
	(1.15)	(1.71)	(1.75)*
s1994	0.006	0.007	0.004
	(0.33)	(0.43)	(0.22)
Constant	-0.207	-0.409	-0.552
	(0.62)	(1)	(1.55)
t statistics in parentheses (* significant at 10%; ** significant at 5%; *** significant at 1%)			
Observations	215	210	210
Number of groups	48	48	48
Number of instruments	41	44	44
Arellano-Bond test for AR(2) in first differences (P-value)	0.223	0.709	0.717
Hansen test of overidentifying restrictions (P-value)	0.193	0.692	0.582
Difference-in-Sargan test (P-value)			
GMM instruments for levels	0.384	0.884	0.705
Predetermined instruments	0.242	0.715	0.658
Endogenous instruments	0.839	0.82	0.815

Notes: Null hypotheses of the tests are as follows: Arellano-Bond test for autocorrelation: null = no autocorrelation; Hansen test: null = the set of instruments is valid; difference-in-Sargan test: null = the level moment conditions imposed in system GMM are valid.

Because budget balance is quite a narrow indicator of institutional quality and because it is already included in Burnside-Dollar policy measure, regressions in Table 3 replace it by a composite index of institutional quality from ICRG. The index measures the level of corruption, bureaucratic quality, and rule of law and is increasing in institutional quality. Moreover, because Sachs-Warner index of openness is also a part of the Burnside-Dollar policy measure, Frankel and Rose (2002) trade instrument based on a gravity model is used here. However, because Frankel-Rose instrument is only calculated for the year 1990, it is time-invariant, and is automatically dropped from difference GMM estimations. Otherwise, the sets of instruments are unchanged. All in all, the results are in line with Table 1. Initial efficiency and investment are the most robust determinants of efficiency change, the former with a positive (remembering that log initial efficiency is included in the regressions) and the latter with a negative impact on efficiency. The interaction term of aid and debt is only significant in regression 2, while it is almost significant and of the same magnitude in regressions 4 and 6. Also the joint impact of aid and policy seems to be significant with a positive coefficient.

Table 3. Difference and system GMM regressions on the impacts of aid and debt on efficiency change

	Regression 1 difference GMM	Regression 2 system GMM	Regression 3 difference GMM	Regression 4 system GMM	Regression 5 difference GMM	Regression 6 system GMM
Efficiency change (lagged)	-0.003	**0.181**	**0.166**	0.123	0.162	0.143
	(0.02)	**(1.98)***	**(1.73)***	(1.02)	(1.52)	(1.4)
Log initial efficiency	**-0.441**	**-0.179**	**-0.477**	**-0.295**	**-0.44**	**-0.259**
	(3.22)***	**(2.32)****	**(4.23)*****	**(3.29)*****	**(4.12)*****	**(2.85)*****
Log initial real GDP / capita	**-0.528**	0	-0.343	0.037	-0.33	0.079
	(1.71)*	(0)	(1.53)	(0.62)	(1.45)	(1.27)
Population growth	0.027	-0.007	0.068	0.011	0.048	0.02
	(0.61)	(0.22)	(2.09)**	(0.34)	(1.18)	(0.53)
Schooling	0.075	0.051	0.228	0.04	0.138	0.015
	(0.38)	(1.04)	(1.22)	(0.73)	(0.72)	(0.34)
Gross fixed capital formation / GDP	**-0.02**	**-0.013**	-0.009	**-0.014**	-0.014	**-0.013**
	(1.71)*	**(3.39)*****	(1.28)	**(3.35)*****	(1.5)	**(3.27)*****
Foreign direct investment / GDP	-0.011	-0.003	-0.028	-0.008	-0.007	-0.008
	(0.41)	(0.25)	(0.91)	(0.76)	(0.28)	(0.93)
Growth rate of net barter terms of trade	0.001	0.002	0.001	0.002	0.002	**0.002**
	(0.49)	(1.41)	(0.6)	(1.31)	(1.06)	**(1.88)***
ICRG	-0.03	-0.011	**-0.031**	-0.019	-0.027	-0.016
	(1.61)	(0.84)	**(2.10)****	(1.35)	(1.53)	(1.17)
Frankel-Rose		0.651		-0.174		-0.078
		(0.56)		(0.1)		(0.05)
Total debt service / exports	-0.001	0.001	0.001	0.001	0	0.001
	(0.32)	(0.25)	(0.48)	(0.45)	(0.02)	(0.57)
Aid (lagged)	0.004	**-0.022**	0.003	-0.026	0.012	-0.011
	(0.18)	**(1.74)***	(0.13)	(1.35)	(0.52)	(0.6)
Aid (lagged) * initial external debt / GDP	0.004	**0.008**	0.001	0.004	0.004	0.006
	(0.93)	**(1.75)***	(0.1)	(1.18)	(1.02)	(1.44)
Aid (lagged) * policy			0.003	**0.016**		
			(0.5)	**(2.07)****		
Debt * policy					0	0.007
					(0.01)	(1.68)
s1982	-0.05	0.068	-0.059	0.035	-0.021	0.015
	(0.38)	(1.37)	(0.6)	(0.56)	(0.26)	(0.35)
s1986	-0.168	-0.069	-0.169	-0.07	-0.133	-0.096
	(1.56)	(1.68)*	(1.78)*	(1.31)	(1.88)*	(2.68)**
s1990	-0.141	-0.016	-0.112	-0.03	-0.084	-0.041
	(1.69)*	(0.55)	(1.68)*	(0.86)	(1.69)*	(1.86)*
s1994	-0.018	0.026	-0.011	0.014	-0.004	0.007
	(0.36)	(1.13)	(0.38)	(0.53)	(0.16)	(0.38)
Constant		0.16		-0.07		-0.408
		(0.44)		(0.16)		(1.16)
t statistics in parentheses (* significant at 10%; ** significant at 5%; *** significant at 1%)						
Observations	178	229	146	195	146	195
Number of groups	49	49	42	45	42	45
Number of instruments	28	40	30	43	30	43
Arellano-Bond test for AR(2) in first differences (P-value)	0.764	0.328	0.917	0.737	0.687	0.672
Hansen test of overidentifying restrictions (P-value)	0.385	0.545	0.825	0.667	0.554	0.651
Difference-in-Sargan test (P-value)						
GMM instruments for levels		0.387		0.776		0.671
Predetermined instruments		0.522		0.619		0.482
Endogenous instruments		0.875		0.696		0.921

Notes: Null hypotheses of the tests are as follows: Arellano-Bond test for autocorrelation: null = no autocorrelation; Hansen test: null = the set of instruments is valid; difference-in-Sargan test: null = the level moment conditions imposed in system GMM are valid.

To summarise, the results indicate that initial efficiency and investment rate are most robustly associated with efficiency change. The impact of initial efficiency is positive, which implies that it may be difficult to catch up in efficiency if the initial level of efficiency is low: an inefficiency trap may exist. Even if we have controlled for aid, debt and the standard measures of policy and institutions, these are bound to capture the phenomena only partially. For example, they do not capture all the possible ways dictatorships could create the trap, and they capture only a subset of institutional variables. But, despite all the caveats, our results provide quite strong evidence for the existence of "inefficiency traps". As to the result on the negative impact of investment rate, it is intuitive in the sense that too heavy investment in physical capital may lead to overcapacity. Physical capital is then used less efficiently than it could be used under other circumstances. In support of the results of Burnside and Dollar (2000, 2004), $aid * policy$ is significant and positive nearly always when it enters system GMM estimations. Also high level of debt, combined with a good policy environment, might increase technical efficiency. Strong policies might, therefore, mitigate the negative incentive effects of expected debt service. Interestingly, evidence of the joint significance of foreign aid and initial debt is also rather strong particularly with budget balance as the measure of institutional quality and Sachs-Warner measure of trade openness. The positive coefficient of the term indicates that aid and debt have jointly a positive impact on efficiency.

4.4 Robustness Checks

If net overseas development assistance (ODA) divided by real GDP is used as the aid variable instead of effective development assistance per real GDP[15], changes in the results of Table 1 are only minor: initial efficiency, population growth, and investment are still the most robust determinants of efficiency change. Also the result concerning the joint significance of aid and initial debt seems to hold: the interaction term is significant and positive if either $aid * policy$ or $debt * policy$ is included in system GMM regressions. The results with the ICRG measure of institutional quality and Frankel-Rose trade instrument presented in Table 3 remain also relatively unchanged with ODA: although $aid * debt$ is not significant at 10 percent risk level in any of the regressions, it is always positive and close to being significant. If one-step regressions are run instead of two-step regressions, $aid*debt$ is significant in regression 1 and with $debt * policy$. Moreover, $aid * policy$ tends to be significant whenever it is included in system GMM estimations. To summarise, the joint impact of aid and policy seems to be more important than that of aid and debt, but even the latter cannot be ruled out despite the use of ODA.

With present value of debt from Dikhanov (2007) as the measure of initial debt, initial efficiency and investment are still significant with similar impacts as before. In system GMM estimations based on Table 1, $aid * debt$ is significant and positive both in one- and two-step variations if $aid * policy$ is included in the analysis but is not significant otherwise. As before, $aid * policy$ is also significant and positive. As to the results of Table 3, $aid*debt$ is insignificant in all two-step system GMM estimations unlike $aid*policy$, which is again significant. In one-step regressions, the joint impact of aid and initial debt is significant in the regression including $debt * policy$. All in all, it seems that the interaction term of aid and initial debt is significant less often with present value of debt than with the nominal value, but its coefficient is still positive and of the same magnitude. Therefore, it seems that the use of present value debt does not completely undermine the joint importance of aid and initial debt. On the other hand, the case for positive impact of aid under good policies is as strong as ever.

So far, we have only used measures of institutional quality and openness as control variables. It is, however, possible, that also geography could play a role in determining the impacts of aid and debt (see for example Dalgaard et al. 2004). To examine whether geography indeed is important, we add tropical area fraction of a country from Roodman (2004) into the analysis. The results are presented in Table 4, which is otherwise based on Table 3. Only system GMM results are presented, because tropical area fraction is time-invariant and disappears, therefore, from difference GMM estimations. The results of both two-step (regressions 1-3) and one-step (regressions 4-6) estimations imply that tropical area fraction is not significant. Instead, initial efficiency and investment enter significantly and with familiar signs. The new aspect raised by the addition of tropical area fraction is the significance of the growth rate of net barter terms of trade, which is now significant and positive in five out of six regressions, implying that external shocks are also important in determining efficiency change. There is again some evidence of the joint significance of aid and initial debt. Also $aid*policy$ is significant and positive, meaning that tropical area fraction did not change the results in any major way. Therefore, institutions (or policy) and, in this case, also trade, seem to prevail over geography.

[15] The results are available upon request.

Table 4. System GMM regressions with tropical area fraction

	Regression 1 two-step	Regression 2 two-step	Regression 3 two-step	Regression 4 one-step	Regression 5 one-step	Regression 6 one-step
Efficiency change (lagged)	**0.189**	0.136	0.168	**0.146**	0.126	0.126
	(2.20)**	-1.12	-1.44	**(1.8)***	-1.43	-1.49
Log initial efficiency	-0.161	**-0.329**	**-0.271**	**-0.145**	**-0.322**	**-0.271**
	-1.67	**(3.83)*****	**(2.58)****	**(2.25)****	**(3.51)*****	**(3.51)*****
Log initial real GDP / capita	0.044	0.04	0.082	0.025	0.033	0.055
	-0.77	-0.69	-1.42	-0.47	-0.58	-1.22
Population growth	-0.007	-0.011	0.012	-0.01	-0.007	0.008
	-0.23	-0.34	-0.3	-0.3	-0.29	-0.29
Schooling	0.018	0.02	0.005	0.054	0.046	0.03
	-0.36	-0.32	-0.11	-1.34	-1.24	-1.02
Gross fixed capital formation / GDP	**-0.014**	**-0.016**	**-0.014**	**-0.016**	**-0.016**	**-0.013**
	(3.76)***	**(3.67)*****	**(3.13)*****	**(4.65)*****	**(4.52)*****	**(4.76)*****
Foreign direct investment / GDP	-0.005	-0.001	-0.006	-0.009	-0.002	-0.007
	-0.47	-0.05	-0.5	-0.96	-0.19	-0.74
Growth rate of net barter terms of trade	**0.003**	0.002	**0.003**	**0.003**	**0.002**	**0.003**
	(1.97)*	-1.56	**(2.34)****	**(2.57)****	**(1.99)***	**(2.36)****
ICRG	-0.005	-0.018	-0.015	-0.014	-0.015	-0.015
	-0.45	-1.25	-1.15	-1.02	-1.43	-1.35
Frankel-Rose	0.361	-0.264	-0.314	0.105	0.268	-0.193
	-0.32	-0.17	-0.21	-0.08	-0.19	-0.17
Total debt service / exports	0.001	0	0.001	0.002	0.001	0.001
	-0.55	-0.02	-0.36	-1.06	-0.29	-0.34
Aid (lagged)	-0.016	-0.027	-0.01	-0.006	-0.023	-0.005
	-1.28	-1.36	-0.52	-0.52	-1.44	-0.48
Aid (lagged) * initial external debt / GDP	0.009	**0.011**	0.011	0.006	**0.011**	**0.009**
	-1.43	**(1.86)***	-1.53	-1.07	**(2.12)****	**(2.07)****
Aid (lagged) * policy		**0.018**			**0.017**	
		(2.22)**			**(2.54)****	
Debt * policy			0.008			**0.006**
			-1.5			**(1.99)***
Tropical area fraction	-0.032	-0.045	-0.031	-0.02	-0.012	-0.027
	-0.87	-1.01	-0.63	-0.46	-0.35	-0.79
s1982	0.044	0.078	0.03	0.052	0.072	0.041
	-0.8	-1.12	-0.61	-1.12	-1.32	-1.01
s1986	-0.09	-0.035	-0.085	-0.097	-0.058	-0.092
	(2.00)*	-0.61	(2.15)**	(2.41)**	-1.32	(2.53)**
s1990	-0.022	-0.006	-0.034	-0.027	-0.01	-0.027
	-0.71	-0.16	-1.51	-0.84	-0.31	-0.96
s1994	0.02	0.02	0.007	0.047	0.02	0.014
	-0.84	-0.8	-0.36	(2.02)**	-1.03	-0.77
Constant	-0.097	0.004	-0.373	0.077	-0.065	-0.22
	-0.24	-0.01	-1	-0.19	-0.13	-0.62
t statistics in parentheses (* significant at 10%; ** significant at 5%; *** significant at 1%)						
Observations	225	194	194	225	194	194
Number of groups	48	44	44	48	44	44
Number of instruments	41	44	44	41	44	44
Arellano-Bond test for AR(2) in first differences (P-value)	0.435	0.646	0.542	0.478	0.753	0.509
Hansen test of overidentifying restrictions (P-value)	0.551	0.662	0.655	0.551	0.662	0.655
Difference-in-Sargan test (P-value)						
GMM instruments for levels	0.491	0.875	0.667	0.491	0.875	0.667
Predetermined instruments	0.449	0.624	0.541	0.449	0.624	0.541
Endogenous instruments	0.647	0.722	0.968	0.647	0.722	0.968

Notes: Null hypotheses of the tests are as follows: Arellano-Bond test for autocorrelation: null = no autocorrelation; Hansen test: null = the set of instruments is valid; difference-in-Sargan test: null = the level moment conditions imposed in system GMM are valid.

As suggested by Roodman (2006), the regressions were also run with forward orthogonal deviations instead of differencing. As opposed to differencing, which subtracts the previous observation from the current observation of a variable, this alternative transformation subtracts the average of all future available observations of a variable. Therefore, the approach minimises data loss and maximises the sample size. The results discussed above are robust to this transformation.

5 Conclusion

Although previous literature on the impacts of both foreign aid and debt is abundant, many questions remain unanswered. First, the results have been conflicting. The empirical methods used have also been lacking. Moreover, the studies have often focused only on aid or debt, and not on both at the same time. The research has also concentrated mostly on the effects on growth with the components of growth receiving less attention. Especially changes in technical efficiency have hardly been studied. Because the results of Haaparanta and Virta (2007) imply that they might have had a significant, and positive effect on labour productivity in developing countries, and particularly so in highly indebted poor countries, examining technical efficiency should not be neglected.

The purpose of this paper was to contribute to the literature on aid and debt by focusing on that particular growth component, technical efficiency, and its changes in aid-recipient countries. First, two models were built to show theoretically that interactions between aid, debt, institutions and donor behaviour affect aggregate productive efficiency. The model concentrating on financial constraints indicated, first, that the connection between debt and growth may differ in countries with different levels of debt and, second, that severeness of debt burden may also affect aid effectiveness in improving technical efficiency. The second model incorporated two political aspects: the ruler's decision of whether to stay in power of not, and the ruler's decision about the level of taxes. The overall conclusions drawn from this framework were that interactions between debt (relief), aid, policy, and efficiency are complicated and that interaction terms of these factors are necessary in empirical work.

The aim of the empirical part was to apply methodology allowing for the endogeneity of several regressors, while at the same time avoiding the pitfalls of explaining efficiency as measured by data envelopment analysis. The system GMM estimations building partly on a set of regressors used by Pattillo et al. (2004) implied that the joint impact of foreign aid and initial debt on efficiency change could be significant and positive. However, the joint impact of aid and policy seemed to be even more significant. The results support, therefore, the findings of Burnside and Dollar (2000, 2004): aid seems to have a positive impact on efficiency, but only in an environment with good policies. All in all, the results seem to confirm that it is important to include interactions of various factors in empirical estimations. As suspected in Haaparanta and Virta (2007), the analysis indicated also that efficiency improvement could have been kind of mandatory in some cases: with a low investment rate, it has been necessary to use the existing resources as efficiently as possible. Finally, the results suggested strongly that "inefficiency traps" may exist, meaning that it can be difficult for economies with low levels of efficiency to catch up with the more efficient ones. This observation is consistent with many theories including the ones presented in the paper. Significantly, our results indicate that a combination of aid and good policies is a way out of the trap. This could explain the efficiency improvement of low-income countries discussed in Section 1.

There are, naturally, many caveats. The results may be sensitive to the measure of efficiency used: an alternative to estimate the efficiency scores would be to use stochastic frontier analysis as in Hermes et al. (2006). Secondly, our method of estimation may not take fully into account the criticism by Simar and Wilson (2006) on the standard practice of estimating the determinants of efficiency. They suggest ways of remedying the problems, another possibility is to use methods of spatial econometrics.

Finally, the exercise here suggests that a potentially useful research agenda would be to combine the decomposition of aid into its components (humanitarian aid separated from other types of aid, project and program aid separated from direct budgetary assistance and so forth) and aid allocation with studying the determinants of the various growth components to get a fuller understanding of aid efficiency and impacts of external debt.

A Appendix

A.1 Data Description

Table A.1. Data descriptions and sources

Variable	Description	Source
Efficiency (log)	DEA-score	Haaparanta and Virta (2007)
		Some series were intrapolated and extrapolated
		due to time period extension and 4-year periods.
Aid	1) Effective development assistance / real GDP	Roodman (2004)
	2) Net overseas development assistance / real GDP	Roodman (2004)
Total debt service / exports	1) Nominal debt / exports	World Bank (2006)
Initial external debt / GDP	1) Nominal debt / GDP	World Bank (2006)
	2) Net present value of debt / GDP	Authors' calculations based on Dikhanov (2007)
Initial real GDP / capita (log)	GDP / capita for the first year of period	Roodman (2004)
Population growth		Roodman (2004)
Schooling	Mean years of secondary schooling among those over 25	Roodman (2004)
Gross fixed capital formation / GDP		World Bank (2006)
Foreign direct investment / GDP		World Bank (2006)
Growth rate of net barter terms of trade		Authors' calculations based on World Bank (2006)
Budget surplus		Roodman (2004)
Sachs-Warner	Index of trade openness updated from Sachs and Warner (1995)	Roodman (2004)
Frankel-Rose	Trade instrument based on Frankel and Rose (2002)	Andrew Rose's home page
Institutional quality	Measures corruption, bureaucratic quality, and rule of law	Roodman (2004)
Tropical area fraction		Roodman (2004)

Note: Original data sources and more detailed variable descriptions for some of the variables are available in Roodman (2004).

Table A.2. Summary statistics

Variable	Obs	Mean	Std. Dev.	Min	Max
Initial efficiency (log)	351	-0.636	0.423	-2.230	0
Effective development assistance / real GDP	351	1.476	2.113	-0.071	12.826
Net overseas development assistance / real GDP	351	2.146	2.824	-0.063	16.013
Initial nominal debt / GDP	327	0.736	0.823	0	10.644
Initial present value of debt / GDP	330	0.449	0.627	0	8.921
Total nominal debt service / exports	317	21.634	13.181	1.079	91.717
Initial real GDP / capita (log)	351	7.629	0.801	5.224	9.788
Population growth	351	2.177	0.961	-2.749	6.578
Schooling	351	1.002	0.717	0.035	4.004
Gross fixed capital formation / GDP	349	21.740	7.365	3.437	59.986
Foreign direct investment / GDP	346	1.960	3.002	-5.166	22.089
Growth rate of net barter terms of trade	337	-0.108	6.366	-23.647	28.907
Budget surplus	313	-0.035	0.056	-0.450	0.153
Sachs-Warner	333	0.448	0.481	0	1
Frankel-Rose	333	0.094	0.109	0.019	0.698
Institutional quality	327	4.610	1.739	0.556	10
Tropical area fraction	339	0.708	0.417	0	1

Note: Summary statistics for those aid recipient countries for which Haaparanta and Virta (2007) calculate DEA-scores. Variables are 4-year averages if not otherwise stated.

A.2 Countries

(data not available for all countries in all regressions, maximum number of countries 57, minimum 45)

Algeria, Argentina, Bangladesh, Bolivia, Botswana, Brazil, Cameroon, Chile, China, Colombia, Congo Democratic Republic, Costa Rica, Dominican Republic, Ecuador, Egypt, El Salvador, Gambia, Ghana, Guatemala, Guyana, Honduras, India, Indonesia, Iran, Jamaica, Jordan, Kenya, Korea, Lesotho, Malawi, Malaysia, Mali, Mauritius, Mexico, Mozambique, Nicaragua, Niger, Pakistan, Panama, Papua New Guinea, Paraguay, Peru, Philippines, Rwanda, Senegal, Singapore, Sri Lanka, Swaziland, Syrian Arab Republic, Thailand, Togo, Tunisia, Uruguay, Venezuela, Zambia, and Zimbabwe

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